

# Ogden Air Logistics Center

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## Making TSP Work at CMMI Level 5



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Carnegie Mellon  
Software Engineering Institute

SSTC 2007

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# Objectives



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- **Present a Case Study**
  - **A CMMI® Level 5 Assessment**
  - **Focusing on a Team Software Process (TSP)<sup>SM</sup> Team**
- **Provide Guidance for TSP Teams**
  - **Does TSP Guarantee CMMI Level 5?**
  - **How can TSP be used to support a CMMI Level 5 Assessment?**
  - **What did this team do to meet CMMI Level 5 objectives?**

The audience should be familiar with the concepts of the TSP and the Personal Software Process (PSP)<sup>SM</sup>

®CMMI is a Registered Trademark of Carnegie Mellon University

<sup>SM</sup>Team Software Process, TSP, Personal Software Process, and PSP are Service Marks of Carnegie Mellon University



# TSP Supports CMMI



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- In the late 1980s and early 1990s the SEI developed the Capability Maturity Model (CMM) which captured organizational best practices for software development
- SEI Fellow, Watts Humphrey, decided to apply the underlying principles of the CMM to the software development practices of a single developer
- The result of this effort was the Personal Software Process (PSP), designed to be a CMM level 5 process for individual software developers
- Humphrey then developed the Team Software Process (TSP) for the smallest operational unit in most organizations, the project team. TSP was designed to be a CMM level 5 process for project teams.

Source: TSP and CMMI: A Brief History (<http://www.sei.cmu.edu/tsp/history.html>)

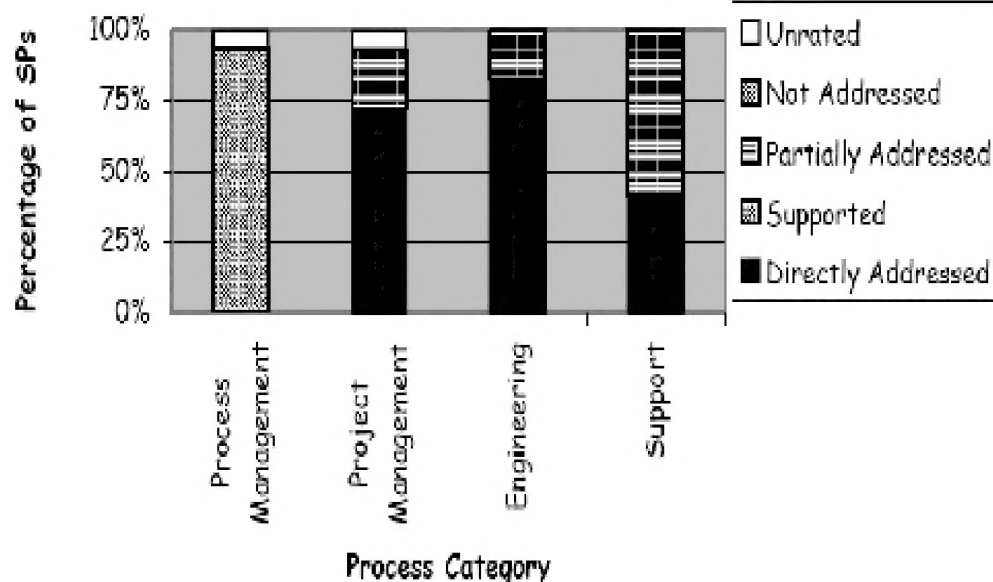


# SEI's TSP to CMMI Mapping – 1



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TSP and CMMI Process Categories



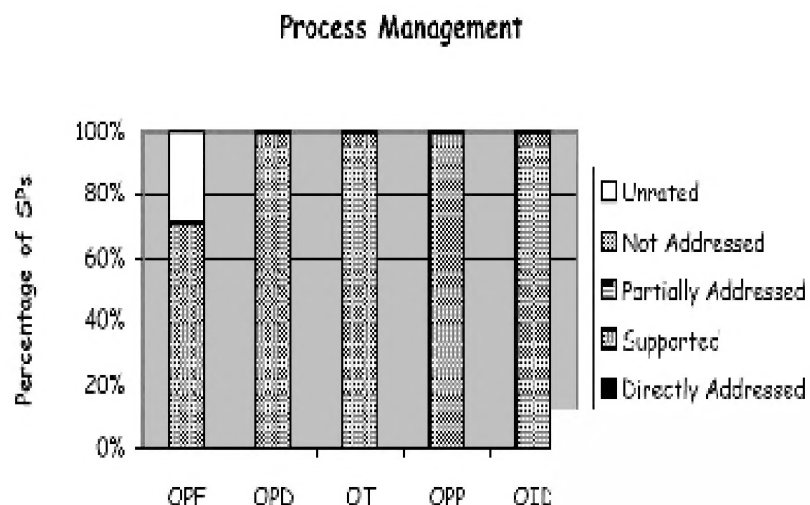
Source: James McHale and Daniel S. Wall Mapping TSP to CMMI (CMU/SEI-2004-TR-014)



# SEI's TSP to CMMI Mapping – 2

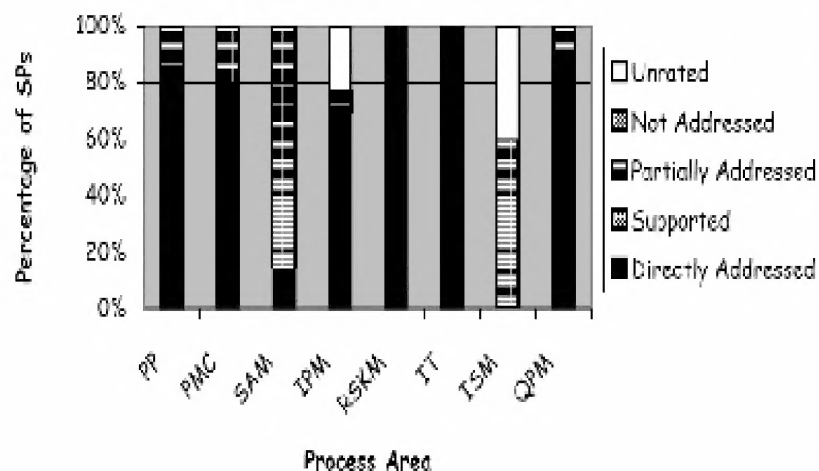


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Process Area

**Project Management**



Source: James McHale and Daniel S. Wall  
Mapping TSP to CMMI  
(CMU/SEI-2004-TR-014)

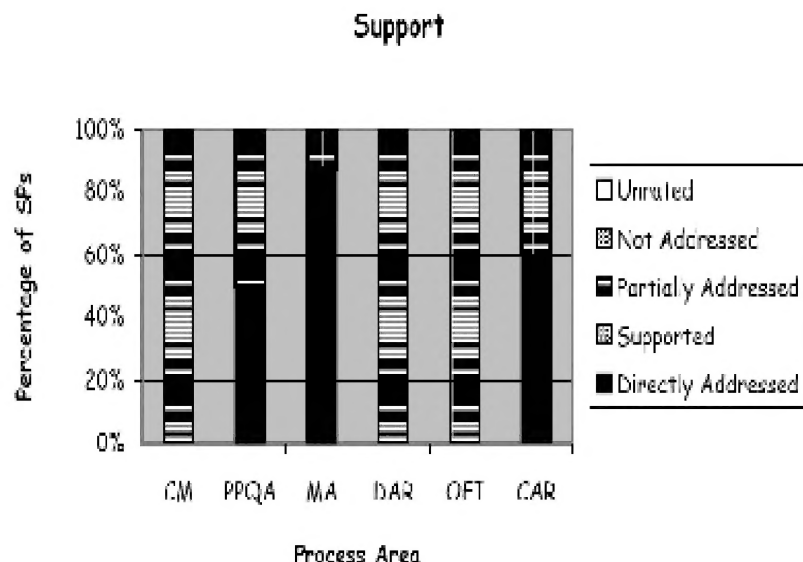
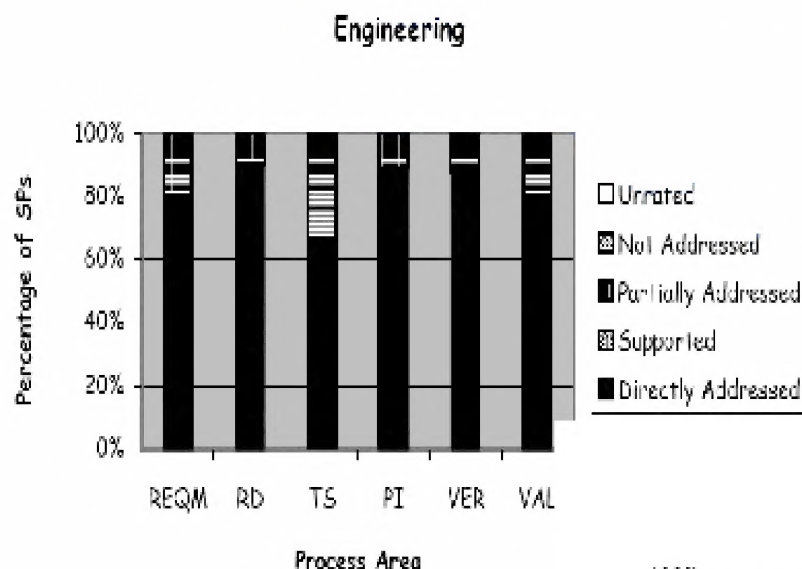




# SEI's TSP to CMMI Mapping – 3



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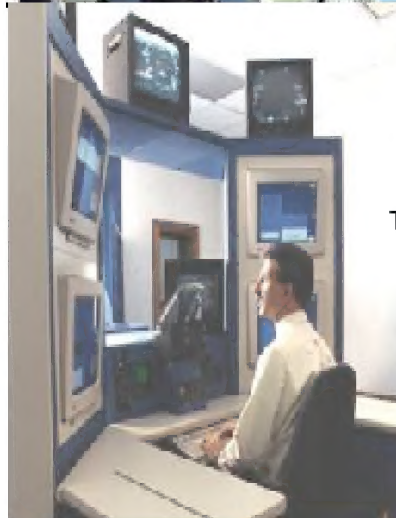
Source: James McHale and Daniel S. Wall  
Mapping TSP to CMMI  
(CMU/SEI-2004-TR-014)



# 309 SMXG Background

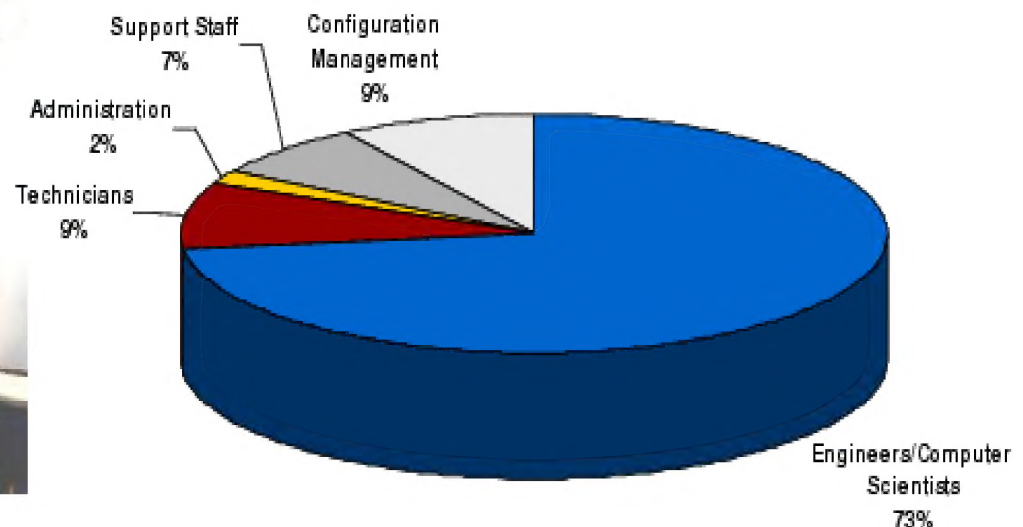


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## ■ Large Cadre of Talented People:

- 700+ Civilian Personnel
- Average over 10 years technical experience
- Growing by ~50 PEs/Year





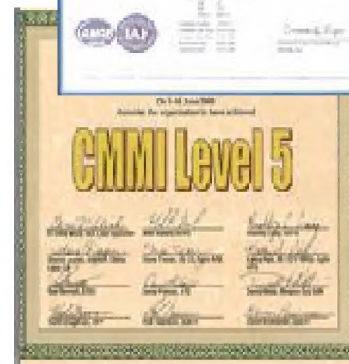
# 309 SMXG

## Process Improvement History



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- Focused on process improvement since 1991
- Assessed in 1998 to be Capability Maturity Model (CMM) - Level 5
- Earned AS9100 & ISO 9001 Registration in 2006
- Assessed in 2006 to be Capability Maturity Model Integration (CMMI) – Level 5



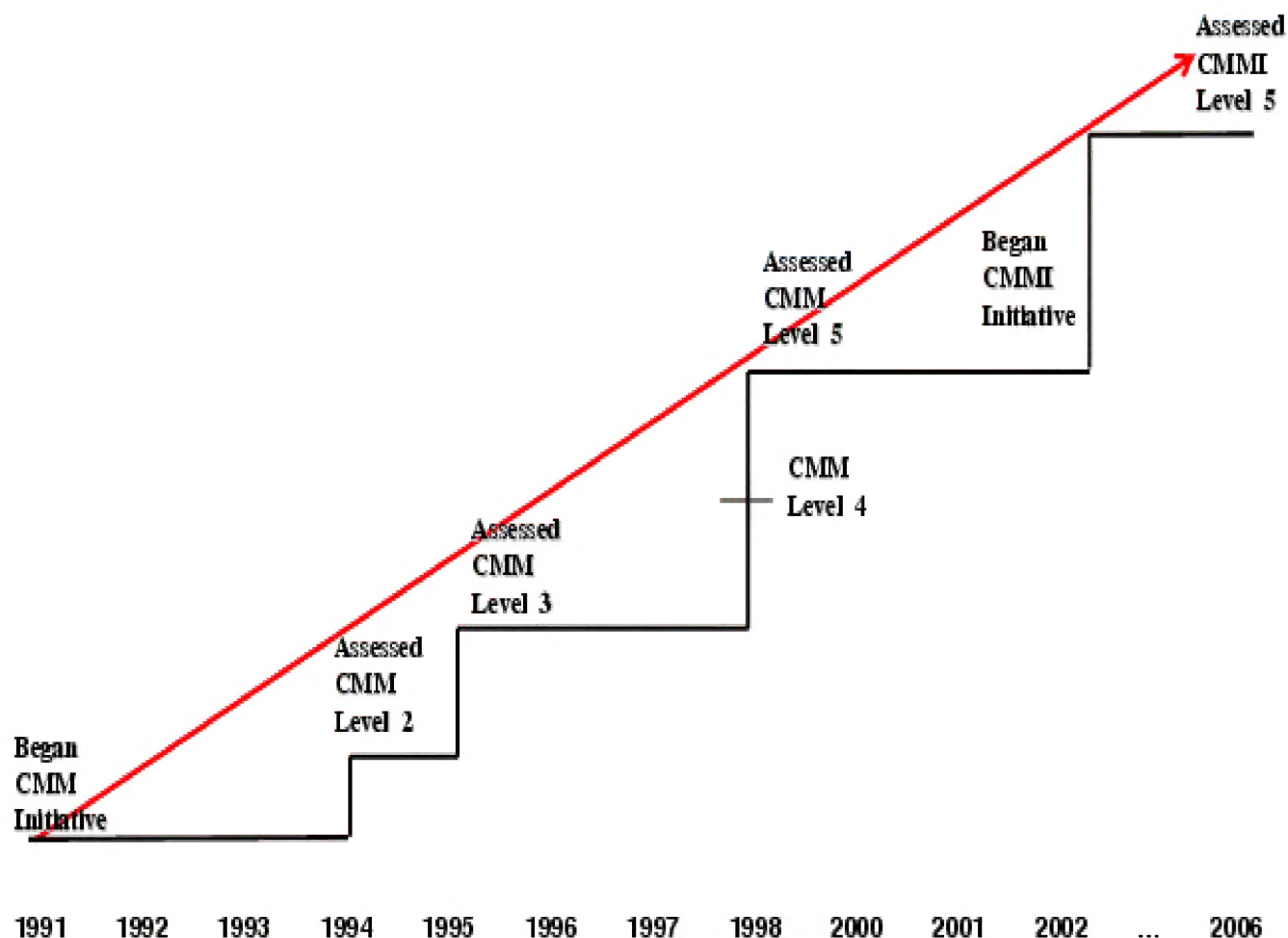




# SMXG & CMM / CMMI



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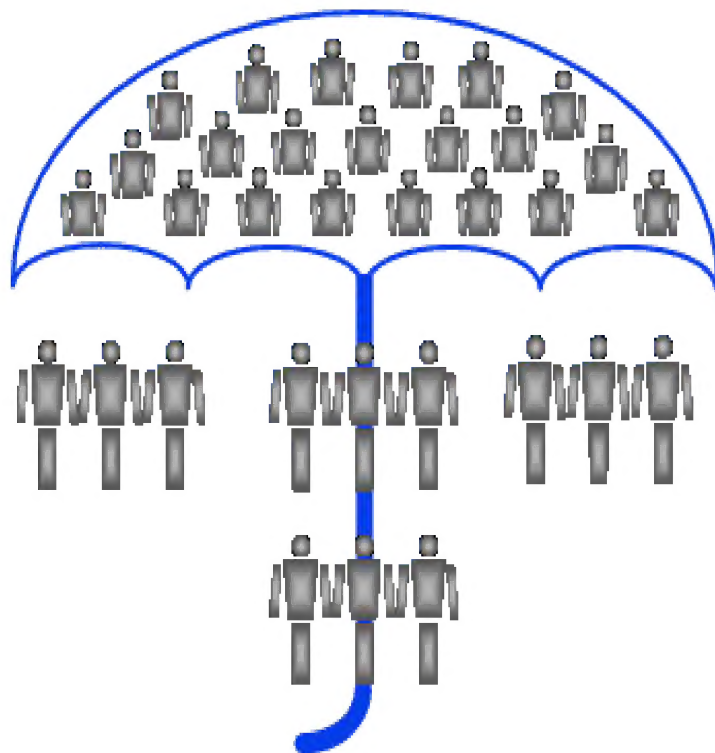
# Focus Project: GTACS



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## CMMI Level 5

Focus Project for CMMI Assessment



**CMMI:** Capability Maturity Model Integration improves the organization's capability; management focus

**TSP:** Team Software Process improves team performance; team and product focus

**PSP:** Personal Software Process improves individual skills and discipline; personal focus

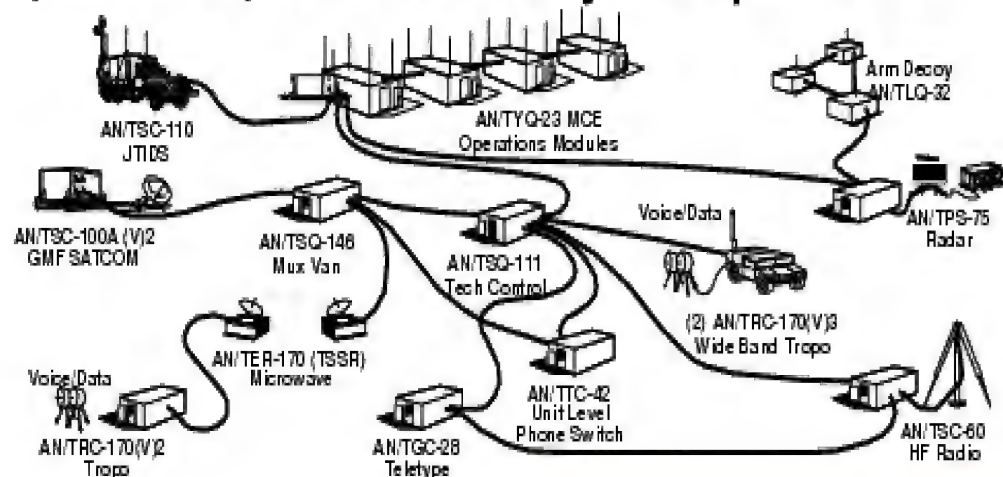


# GTACS Overview



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- **Ground Theater Air Control System (GTACS)**
  - **Modular Control Equipment (MCE) & Tactical Air Operations Modules (TAOM)** create a ground-based computer network systems that coordinate radar and communications data signals. GTACS modules coordinate ground, airborne, and naval elements to plan, execute, and evaluate joint operations.





# GTACS MCE Software Updates



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## ■ 309 SMXG provides Module Control Equipment (MCE) software updates for:

### ■ New Features:

- Updates to MIL-STD Communications Protocols
- User-Initiated Switch Action & Display Changes
- Interfaces with New Weapons and Systems

### ■ Defect Corrections:

- Software Development Defects
- Government Acceptance Test Defects
- Field-discovered Problem Reports



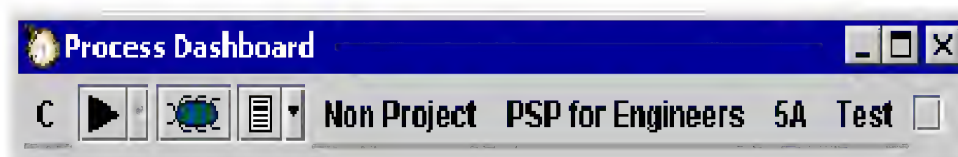


# GTACS TSP Tracking Tools



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- **GTACS Uses The Process Dashboard Tool to:**
  - support individuals and the team in using high-maturity processes for software development
  - simplify the work involved in following a high-maturity process
  - help individuals to follow a defined process and collect metrics data
  - improve the accuracy of collected metrics







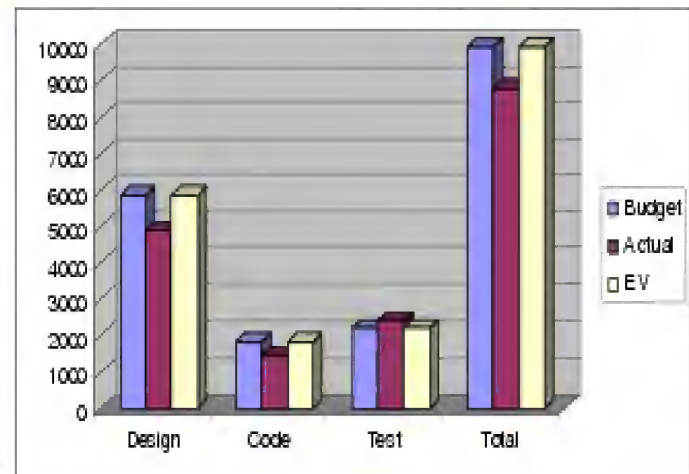
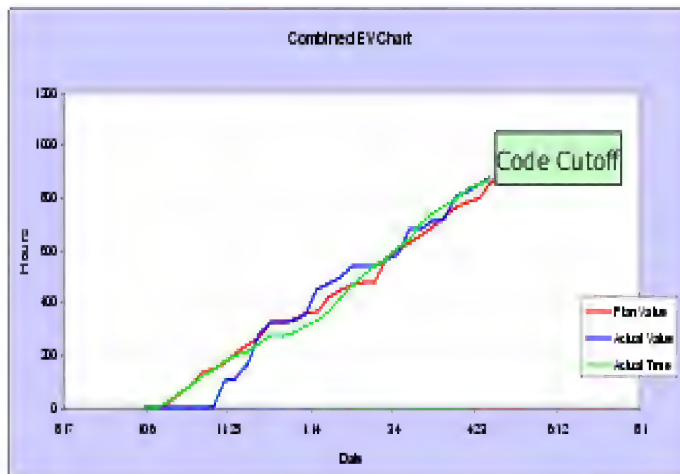
# GTACS & TSP: Productivity



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- TSP Schedule Improvement
  - Zero missed deadlines
  - Zero “returned” workload
- TSP Quality Improvement
  - Zero integration defects
  - Zero integration rework

- TSP Productivity Improvement
  - 417% increase in SLOC/Hour!
  - Completely recouped TSP investment cost after about 1 month!





# GTACS & TSP: Quality



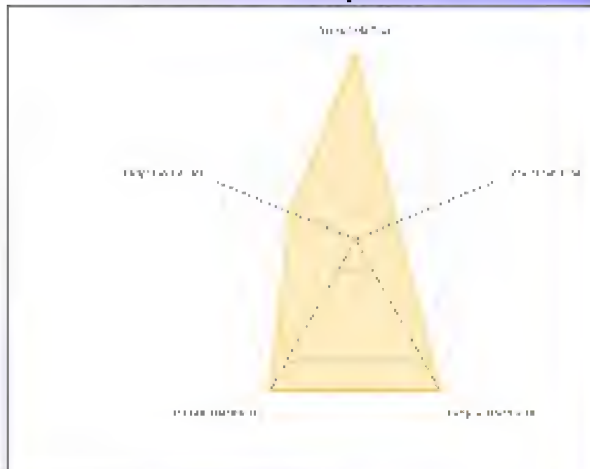
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- TSP Promotes High Quality Processes
  - Personal Reviews
  - Team Peer Reviews
  - Integrated Systems Engineering Peer Reviews
- GTACS Team Achieves 99.4% Defect Removal Before Release

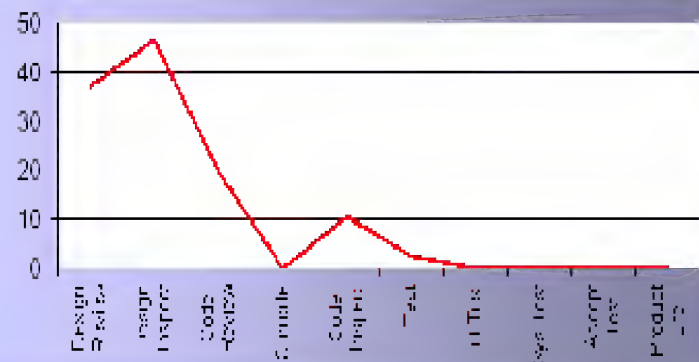
## Process Yields

	Plan	Actual
% Before Compile	97.4%	99.1%
% Before Unit Test	97.2%	99.1%
% Before Build and Integration Test	99.0%	99.4%
% Before System Test	99.9%	99.4%

Quality Profile



Defect Removal Profile





## **309 SMXG CMM / CMMI Assessments**



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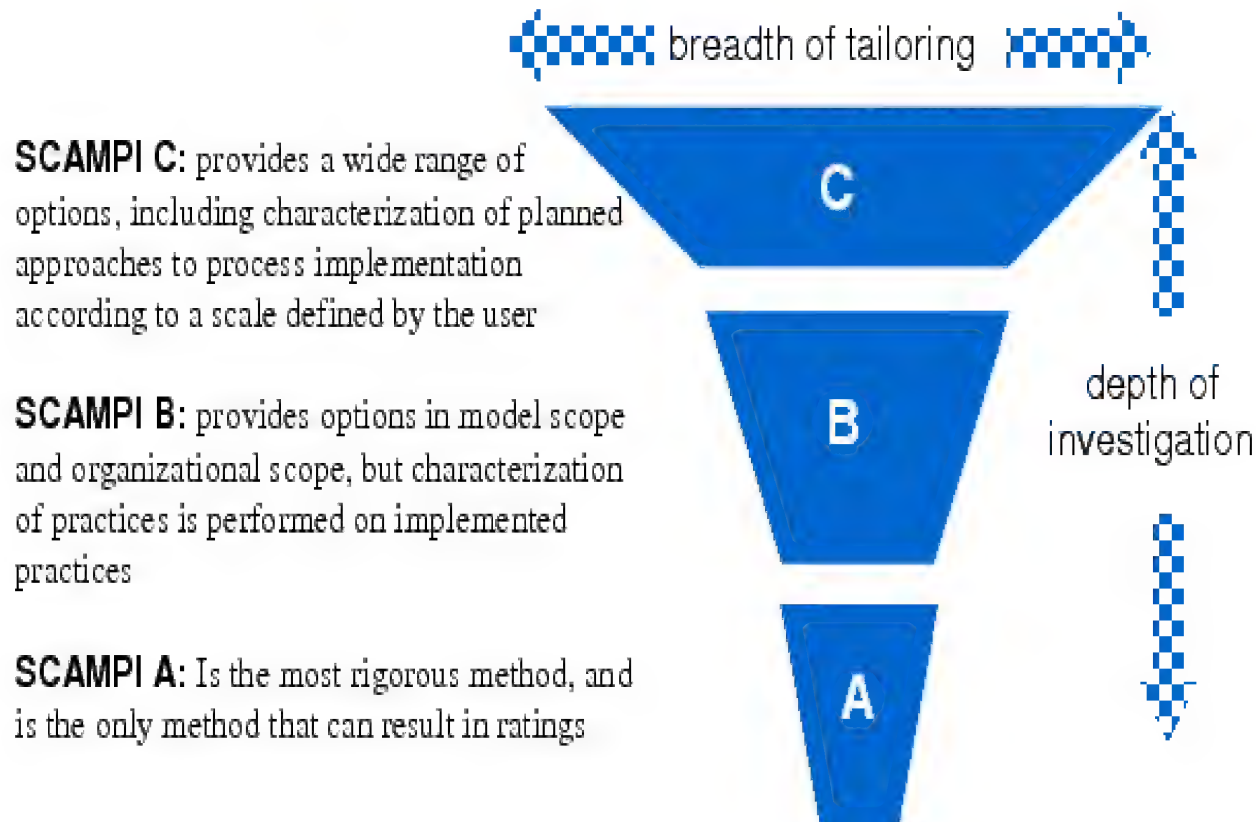
- **1998: Assessed SW-CMM Level 5**
- **2001: Evaluated Moving to CMMI vs Another SW-CMM Assessment**
- **2003: Began CMMI Transition**
- **2005: Performed Two SCAMPI B's on Potential Focus Projects**
- **2006: Performed SCAMPI A on Focus and "Depth" Projects**



# SCAMPI Family of Appraisals



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# SCAMPI B #1 Results – 1

GTACS Project Only\*



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	REGM	PP	PMC	SAM	M&A	PPQA	CM	RD	TS	PI	Var	Vsl	OPF	OPD	OT	PM	RSGM	IT	ISM	DAR	CEI	OPP	QPM	OID	CAR	
Specific Goal 1																										
SP 1.1	L	L	L		L		M	L	M	L	L	L				L	M					M	L		H	
SP 1.2	L	L	L		L		L	L	L	L	L	L				L	L					M	L		H	
SP 1.3	H	L	L		L		L		L	M	L	L				L	L					M	L			
SP 1.4	L	L	H		L											L						M	L			
SP 1.5	L		H													M						M				
SP 1.6			L																							
SP 1.7			L																							
Specific Goal 2																										
SP 2.1	L	L			L		M	L	L	L	L	L				L	L						L		H	
SP 2.2	L	L			L			L	L	L	L	L				L	L						M		H	
SP 2.3	H	L						L	L		L	L				L	L						M		M	
SP 2.4	L				L				M														L			
SP 2.5																										
SP 2.6	H																									
SP 2.7	M																									
Specific Goal 3																										
SP 3.1	L						L	L	L	L	L					L										
SP 3.2	L						M	L	L	L	L	L					M									
SP 3.3								L																		
SP 3.4	M							L																		
SP 3.5								L																		
Specific Goal 4																										
SP 4.1																										
SP 4.2																										
SP 4.3																										
Generic Goal 2																										
GP 2.1	L	L	L		L		L	L	L	L	L	L				L	L					L	L		L	
GP 2.2	L	L	L		M		L	L	L	L	L	L				L	L					L	L		L	
GP 2.3	L	L	L				L	L	L	L	L	L				L	L					L	L		L	
GP 2.4	L	L	L				L	L	L	L	L	L				L	L					L	L		L	
GP 2.5	M	M	M		M		L	M	L	L	L	L				M	M					M	M		M	
GP 2.6	L	L	L				L	L	L	L	L	L				L	L					L	L		L	
GP 2.7	M	M	L				M	M	L	M	L	L				L	L					L	L		L	
GP 2.8	L	L	L		L		L	L	L	L	L	L				L	L					L	L		L	
GP 2.9	L	L	L		L		L	L	L	L	L	L				L	L					L	L		L	
GP 2.10	L	L	L		L		L	L	L	L	L	L				L	L					L	L		M	
Generic Goal 3																										
GP 3.1	H	L	L		L		M	L	L	L	L	L				L	L					L	L		L	
GP 3.2	L	L	L		L		M	L	L	L	L	L				L	L					L	L		L	

LEGEND	
L	Low Risk
M	Medium Risk
H	High Risk

\*IPPD PA's not addressed. PPQA, OPF, OPD, OT and DAR were assessed at the Organizational level. SAM was N/A for GTACS.





# SCAMPI B #1 Results – 2

## GTACS Project Only



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Risk Level	Total Risks	Process Risks	Artifact Risks	Document Risks	Non-Team Risks
High	19	1	17	0	1
Medium	67	15	18	6	28
Low*	0	0	0	0	0
Total	86	16	35	6	29

\*Low risks were not categorized in the first SCAMPI B

### ■ Definitions

#### ■ Risk Level

- the risk that the final SCAMPI A Assessment will have a negative finding

#### ■ Process Risks

- the GTACS team had no process in place

#### ■ Artifact Risks

- the assessment team found insufficient artifacts to assess

#### ■ Document Risks

- GTACS process documentation needed to be updated

#### ■ Non-Team Risks

- the responsibility of a team other than the TSP team, such as the group's SEPG or the GTACS CM Team



# SCAMPI B #1 Actions



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- **Addressed Causal Analysis & Resolution (CAR) Findings (High Risk)**
  - Focused on executing CAR process
  - Gathered data / created CAR artifacts
- **Process Framework & Documentation**
  - Identified missing elements (Requirements Management, Project Planning, Project Monitoring & Control)
  - Created/Implemented Process Improvement Proposals
- **Team Resources**
  - No special resources devoted to CMMI
  - Work was done by the team and led by the team's process manager (a standard TSP role)



# SCAMPI B #2 Results – 1

GTACS Project Only\*



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	RESCM	PP	PINC	SAM	MAA	PPQA	CM	RD	TS	PI	V <sub>1</sub>	V <sub>2</sub>	OPF	ODP	OT	IPM	RSKM	IT	ISM	DAR	OE	OPF	OPM	OD	CAR
<b>Specific Goal 1</b>																									
SP 1.1	L	L	L		L	L	L	L	M	L	L	M	L	L		L	L			L		H	L	L	L
SP 1.2	L	L	L		L	L	L	L	M	L	L	L	L	L		L	M			H		H	L	L	L
SP 1.3	L	L	L		L	L	L	L	M	L	L	L	L	L		L	L			H		H	L	L	L
SP 1.4	M	L	M		L					L	L					L				H		H	L	L	L
SP 1.5	L															L				H		H			
SP 1.6			L																	H		H			
SP 1.7			L																	H		H			
<b>Specific Goal 2</b>																									
SP 2.1	L	L			M	L	L	L	L	M	L	L	L	L			L	L					L	L	L
SP 2.2	L	L			L	L	L	L	L	L	L	L	L	L			L	M					M	L	M
SP 2.3	L	L									L	L					L						M	M	L
SP 2.4	L	L			L				M					L									M		
SP 2.5	L																								
SP 2.6	L																								
SP 2.7	L																								
<b>Specific Goal 3</b>																									
SP 3.1	L							L	L	L	L	L	L				L								
SP 3.2	L							L	L	L	L	L	L				L								
SP 3.3	L							L																	
SP 3.4								L																	
SP 3.5								L																	
<b>Specific Goal 4</b>																									
SP 4.1																									
SP 4.2																									
SP 4.3																									
<b>Generic Goal 2</b>																									
GP 2.1	L	L	L		L	L	L	L	L	L	L	L	L	L		L	L			L		M	L	L	L
GP 2.2	L	M	L		L	L	L	L	L	L	L	L	L	M	M		L	L			H		H	L	L
GP 2.3	L	L	L		L	L	L	L	L	L	L	L	L	L		L	L			L		H	L	L	L
GP 2.4	L	L	L		L	L	L	L	L	L	L	L	L	L		L	L			L		H	L	L	L
GP 2.5	M	M	M		M	H	L	M	M	M	M	L	L	L		M	M			M		H	L	H	M
GP 2.6	L	L	L		L	L	L	L	L	L	L	L	L	L		L	L			M		H	L	L	L
GP 2.7	L	L	L		L	L	L	L	L	L	L	L	L	L		L	L			M		H	L	L	L
GP 2.8	L	L	L		L	L	L	L	L	L	L	L	L	M	M		L	L			H		H	L	L
GP 2.9	L	L	L		L	L	L	L	L	L	L	L	L	L		L	L			L		H	L	L	L
GP 2.10	L	L	L		L	M	L	L	L	L	L	L	L	L		L	L			L		L	L	L	L
<b>Generic Goal 3</b>																									
GP 3.1	L	L	L		L	L	L	M	L	L	L	L	L	L		L	L			L		H	L	L	L
GP 3.2	L	L	L		L	L	L	L	L	L	L	L	L	L		L	L			H		H	L	L	L

LEGEND	
L	Low Risk
M	Medium Risk
H	High Risk

\*For this SCAMPI B, PPQA, OPF, ODP, and DAR were assessed at the Project level. OT was Org level. SAM was N/A for GTACS.



# SCAMPI B #2 Results – 2 GTACS Project Only



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Risk Level	Total Risks	Process Risks	Artifact Risks	Document Risks	Non-Team Risks
High	23	0	8	0	15
Medium	38	7	6	17	8
Low	22	0	1	11	10
Total	83	7	15	28	33

## ■ Decision Analysis & Resolution (DAR):

- 7 High, Artifact
- 3 Medium, Artifact
- 1 Low, Document

## ■ Organizational Process Performance (OPP):

- 13 High, Non-Team
- 1 Medium, Non-Team
- 1 Low, Non-Team

## ■ Training:

- 1 High, Artifact
- 2 High, Non-Team
- 12 Medium, Document
- 1 Low, Artifact
- 1 Low, Non-Team

## ■ Others with GTACS responsibility:

- 18 Medium - 17 Low
- Spread throughout model
- QPM, CAR, and Risk Management required process changes





# DAR Findings



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## ■ Scope

- During 1<sup>st</sup> SCAMPI B, DAR was focused at the organizational level
- This proved to be insufficient to produce the necessary artifacts
- An Organization level DAR process was developed by representatives throughout the 309<sup>th</sup>
- The new DAR process became a requirement for GTACS

## ■ Timing

- The majority of the time between the first and second SCAMPI B's was spent at the Organizational level
- GTACS defined its process, conducted training, but did not execute the process prior to the second SCAMPI B

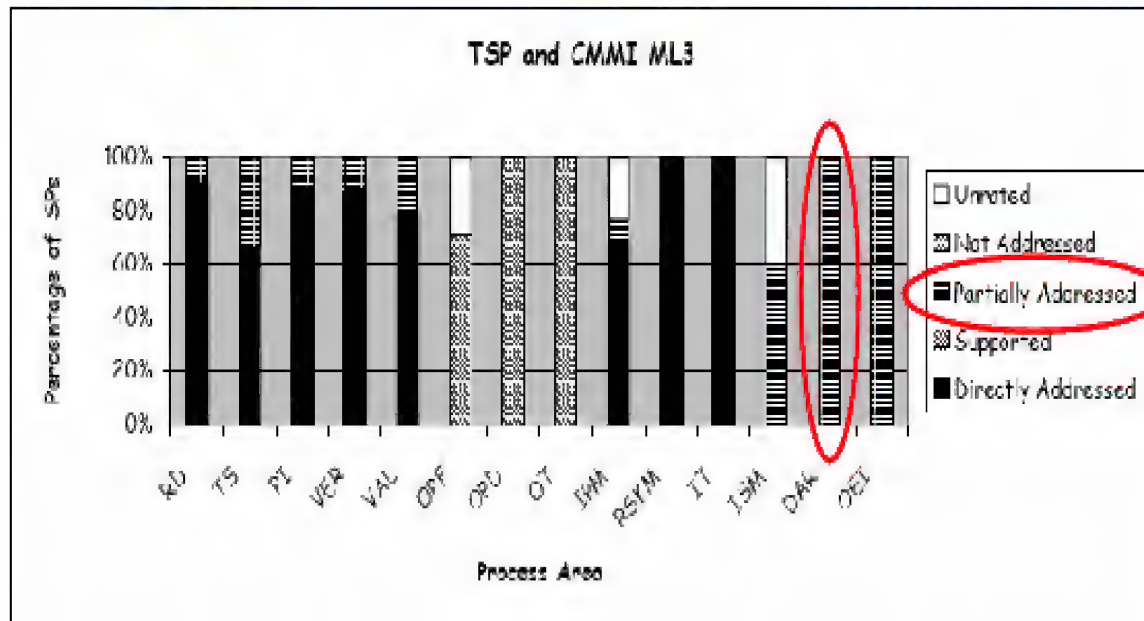




# DAR “Supported” by TSP



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- SEI's Report: All DAR Specific Practices “Partially Addressed”
- Underestimates Risk and Effort for TSP Teams
  - TSP is consistent with DAR philosophy but is nowhere near sufficient
  - TSP as it now stands is insufficient to pass a CMMI assessment
  - TSP DAR procedure is required to produce proper and meaningful artifacts



# DAR for GTACS TSP Team



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## ■ Institutionalization

- The 309<sup>th</sup> provided DAR training for GTACS
- GTACS adapted the Organization level DAR process for use on their team
- Determined to use the TSP approach
  - Scripts
  - Forms

## ■ Adaptation

- GTACS created a draft operational process in the form of a TSP script
- The DAR script was then used to analyze several different types of issues
  - product design
  - tool selection
  - process



# DAR TSP Script for GTACS



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## DAR Process Script

Purpose	To guide the team in making formal decisions.
Entry Criteria	Either - A Critical measurement exceeds the thresholds defined in the GTACS DAR threshold matrix or - A critical decision needing a formal analysis is identified.
General	- Critical decisions are ones that have potential impact on the project or project team. Issues with multiple alternative approaches and multiple evaluation criteria are particularly well suited for formal analysis..
Tailoring	- This procedure may be used to make and document other decisions

Step	Activities	Description
1	Planning	<ul style="list-style-type: none"><li>- A POC is assigned<ul style="list-style-type: none"><li>• The POC may be self assigned if the POC is responsible for the critical decision</li><li>• The team lead assigns the POC otherwise</li></ul></li></ul> <p>The team that will perform the DAR analysis and selection activities (the DAR team) is assigned</p> <ul style="list-style-type: none"><li>- The POC completes the Entry section of the MXDE Decision Analysis and Resolution Coversheet (section I)</li></ul>

		<ul style="list-style-type: none"><li>• The completed MXDE Decision Analysis and Resolution Coversheet</li><li>• Scoring and analysis worksheets</li><li>• CM is notified that the DAR is complete and that the DAR artifacts can be archived to the GTACS data management repository</li></ul>
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Exit Criteria	<ul style="list-style-type: none"><li>- The MXDE Decision Analysis and Resolution Coversheet is completely filled out</li><li>- The artifacts produced during the DAR activities have been archived in accordance with the GTACS DMP</li></ul>
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Note: The entire process script can be found in the Crosstalk article "CMMI Level 5 and the Team Software Process"



# OPP and QPM



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- **GTACS Weaknesses in OPP and QPM**
  - GTACS data were not analyzed at the sub-process level
  - Data analyses did not address an understanding of process variability
- **TSP Paradigm is Not Consistent with CMMI Expectations**
  - TSP fundamentally considers the software development process as a single entity
  - CMMI expects that some sub-processes be statistically analyzed during project execution
  - TSP teams use data for three purposes:
    - project planning (whole process)
    - project monitoring and oversight (whole process)
    - process improvement (possibly by sub-process, but during Postmortems)
  - TSP uses statistical tools such as Pareto and linear regression
  - CMMI often expects run charts and a more formal statistical analysis



- Helping the Organization address Organizational Process Performance requirements by Organizational Subprocess (Process Category)
- Mapping detailed TSP project data to Organizational data structures
- Using Organizational goals to guide data analyses

Wilhelmus Heilmann





# QPM Solutions – 1



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## ■ Utilized Existing TSP Data

### ■ Earned Value

- For project management, the Projected Completion Date is one of the key items of interest
- GTACS had more than one year's worth of statistically significant data on Earned Value

### ■ Rework

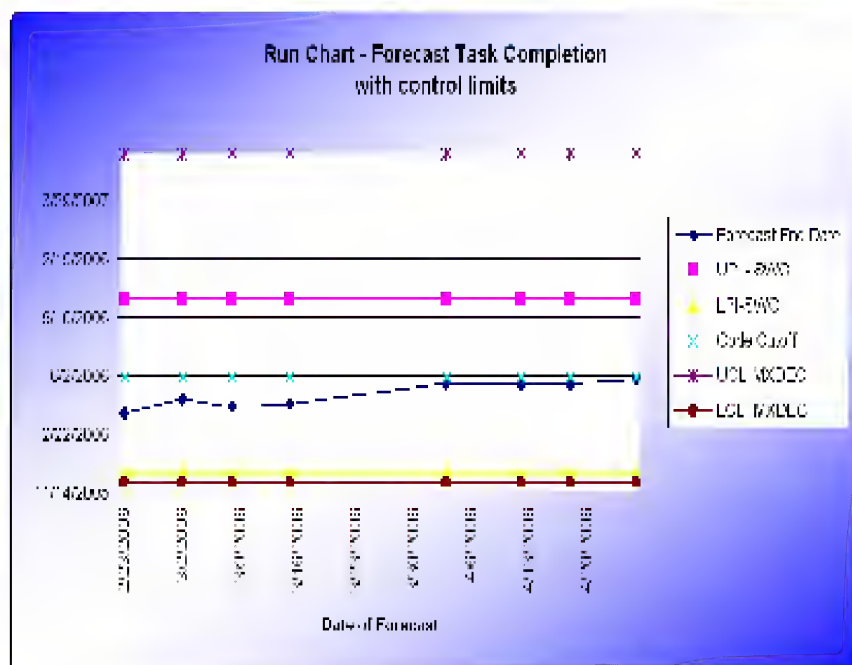
- TSP teams collect a great deal of Defect data, including time spent in the finding and fixing of defects
- GTACS defined Rework as the percent of total project time spent finding and fixing defects (consistent with the Organizational definitions)
- GTACS had more than one year's worth of statistically significant data on Rework



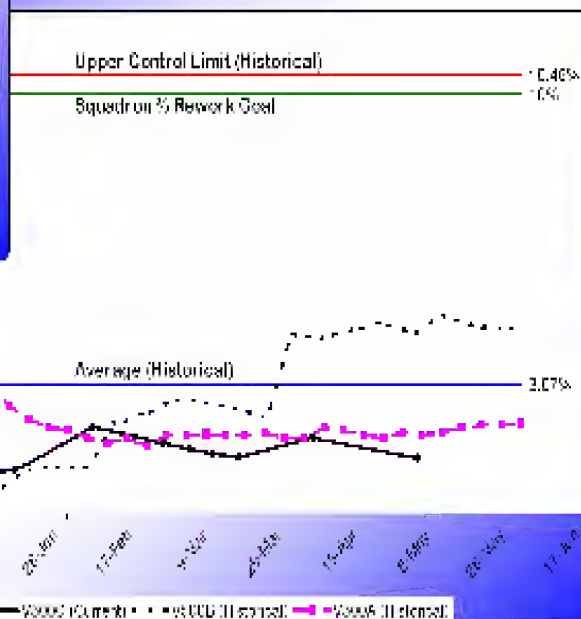
# QPM Solutions – 2



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## GTACS % Rework



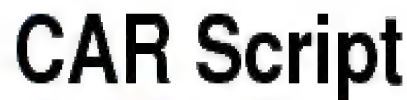


# CAR



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- **TSP Postmortem Process**
  - Currently calls for a detailed analysis of project and process data, including identification of improvements
  - This provides a great deal of support for CAR
- **TSP Postmortem Lacks CAR “Formality” and “Feedback”**
  - CAR artifacts not specifically defined nor required
  - No examination of data to determine if implemented process improvements really worked
- **GTACS Updated the Phase Postmortem Script**
  - Directly addresses Causal Analysis and Resolution
  - Created a CAR Report
    - Details the data analysis which was performed
    - Identifies any weaknesses discovered
    - Suggests process improvements to address these weaknesses
    - Requires an analysis of previous project improvements



## TSP Postmortem Script

Step	Activities	Description	6	Process Causal Analysis	The team lead leads the team in an analysis of the team's process capability
1	Meeting Roles	<ul style="list-style-type: none"> <li>- The team lead</li> <li>- The team</li> <li>- The team</li> <li>- The team</li> <li>- The team</li> <li>- The team</li> </ul>			<ul style="list-style-type: none"> <li>- A discussion is held of key process capabilities (e.g., estimation accuracy, productivity, quality) and compared with desired numeric goals</li> <li>- A determination is made to identify any process capability deficiencies that exist or if there are process capability improvement opportunities.</li> </ul> <p>Key process capabilities are analyzed</p> <p>Where improvement opportunities are identified</p> <p>Identify process, training, tool, support, or management actions</p> <p>Submit GCARs as required</p>
2	Baseline Evaluation	The team	7	Quality Causal Analysis	The quality manager leads the team in an analysis of the team's defect data
3	Plan Evaluation	The plan			<ul style="list-style-type: none"> <li>- A determination of which defects to analyze is made through an analysis of: Pareto charts for the most costly and most common defect types</li> </ul> <p>All defect escapes from Unit Test</p>
4	Quality Performance	The quality			<ul style="list-style-type: none"> <li>- For those defects and defect types selected:</li> </ul> <p>Their defect log entries are analyzed to determine root cause</p> <p>Where improvement is needed</p> <p>Identify process (e.g., checklist(s) update), training, tool, support, or management actions</p> <p>Submit GCARs as required</p>
5	Planning Data	Provide u			
6	Process Causal Analysis	The team			





# CAR Report



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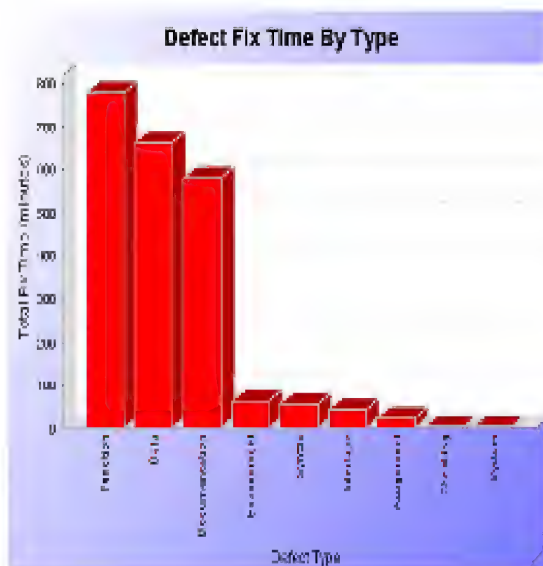
## V500A Causal Analysis and Resolution

### 1 Selecting Defects for Problem Analysis

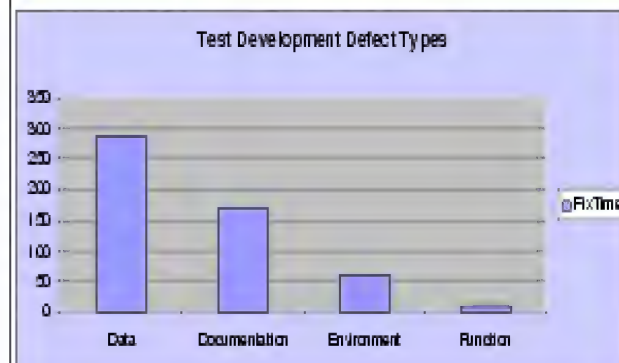
During the post-mortem phase for V500A an analysis of the defect data was performed in an attempt to find ways to improve our process and our product quality. The focus of the analysis was to find the kind of errors that were the most expensive to correct or perhaps occurred most frequently. We also wanted to look at problems that occurred during the V500A development phase that were possibly not logged as defects but cost the team in terms of schedule.

#### 1.1 Most Common Defect

The initial V500 Defect data showed that the most expensive type of defect was type function.

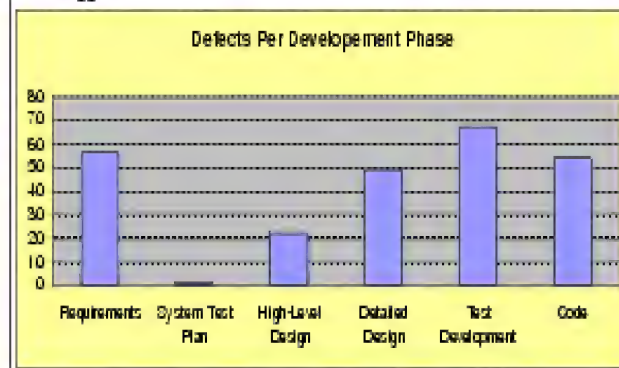


The GTACS defect type of data is defined to be any defect caused by the improper design or implementation of a data element. This type of error also happens to be the most expensive error type logged by our team for errors in the test development phase.



#### 1.1 Defects by Phase

Another metric that was evaluated was the total number of defects injected in a development phase of our process. The Test Development Phase has the most total defects logged.





# Training



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- **TSP Training Covers Many CMMI Requirements**
  - **Personal Software Process Training for Engineers**
  - **Managing TSP Teams for Managers & Team Leader**
  - **Addressed the training requirement (SP 2.5) for:**
    - Project Planning
    - Project Monitoring & Control
    - Integrated Project Management
    - Process and Product Quality Assurance
    - Measurement & Analysis
    - Causal Analysis & Resolution
    - Verification (partially addressed)
- **A Training Plan was Developed for the Remaining Process Areas**



# Summary



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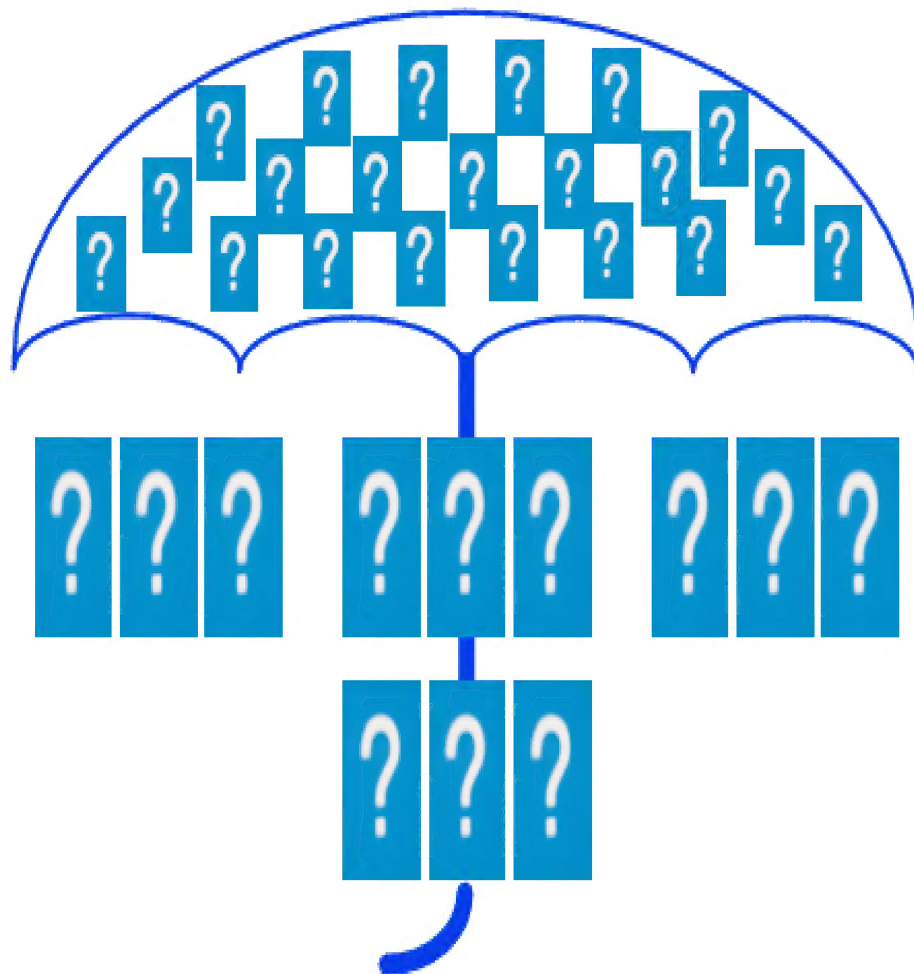
- **TSP Does Not Guarantee CMMI Level 5**
- **SEI's Mapping of TSP to CMMI is a Good Starting Point**
- **TSP Teams Should Focus on:**
  - **Causal Analysis & Resolution**
  - **Decision Analysis & Resolution**
  - **Organizational Process Performance**
  - **Quantitative Project Management**
  - **Training**
- **TSP Does Provide All the Data and Discipline Required**
- **Additional Scripts, Forms and Reports are Needed**



# Questions?



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# Contact Information



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# Acronyms

OGDEN AIR LOGISTICS CENTER

- **309 SMXG:** 309th Software Maintenance Group
- **CAR:** Causal Analysis and Resolution
- **CM :** Configuration Management
- **CMMI:** Capability Maturity Model Integration
- **DAR:** Decision Analysis and Resolution
- **GTACS:** Ground Theater Air Control System
- **MIL-STD:** Military Standard
- **OPP:** Organizational Process Performance
- **PSP:** Personal Software Process
- **QPM:** Quantitative Project Management
- **SCAMPI:** Standard CMMI Appraisal Method for Process Improvement
- **SEI:** Software Engineering Institute
- **SEPG:** Software Engineering Process Group
- **SP:** Specific Practice (in the CMMI)
- **TSP:** Team Software Process